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IMPACT OF THE VILLAGE OF NORWOOD SEWAGE TREATMENT PLANT EFFLUENT ON THE WATER QUALITY OF THE OUSE RIVER

COUNTY OF PETERBOROUGH

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Ministry of the Environment

The Honourable
Harry C. Parrott, D.D.S.,
Minister

Graham W. S. Scott,
Deputy Minister

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COUNTY OF PETERBOROUGH

Field Work 1977

Report 1980

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Report Prepared By

Water Resourses Assessment

Technical Support Section

Central Region

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

In response to a request from staff of the Municipal & Private Abatement Section, a water quality survey of the Ouse River was carried out to:

1) define the existing water quality of the river in relation to the sewage treatment plant discharge at the Village of Norwood;

2) determine whether further expansion of the Village of Norwood sewage treatment facilities would significantly effect the stream water quality in the future.

THE SURVEY

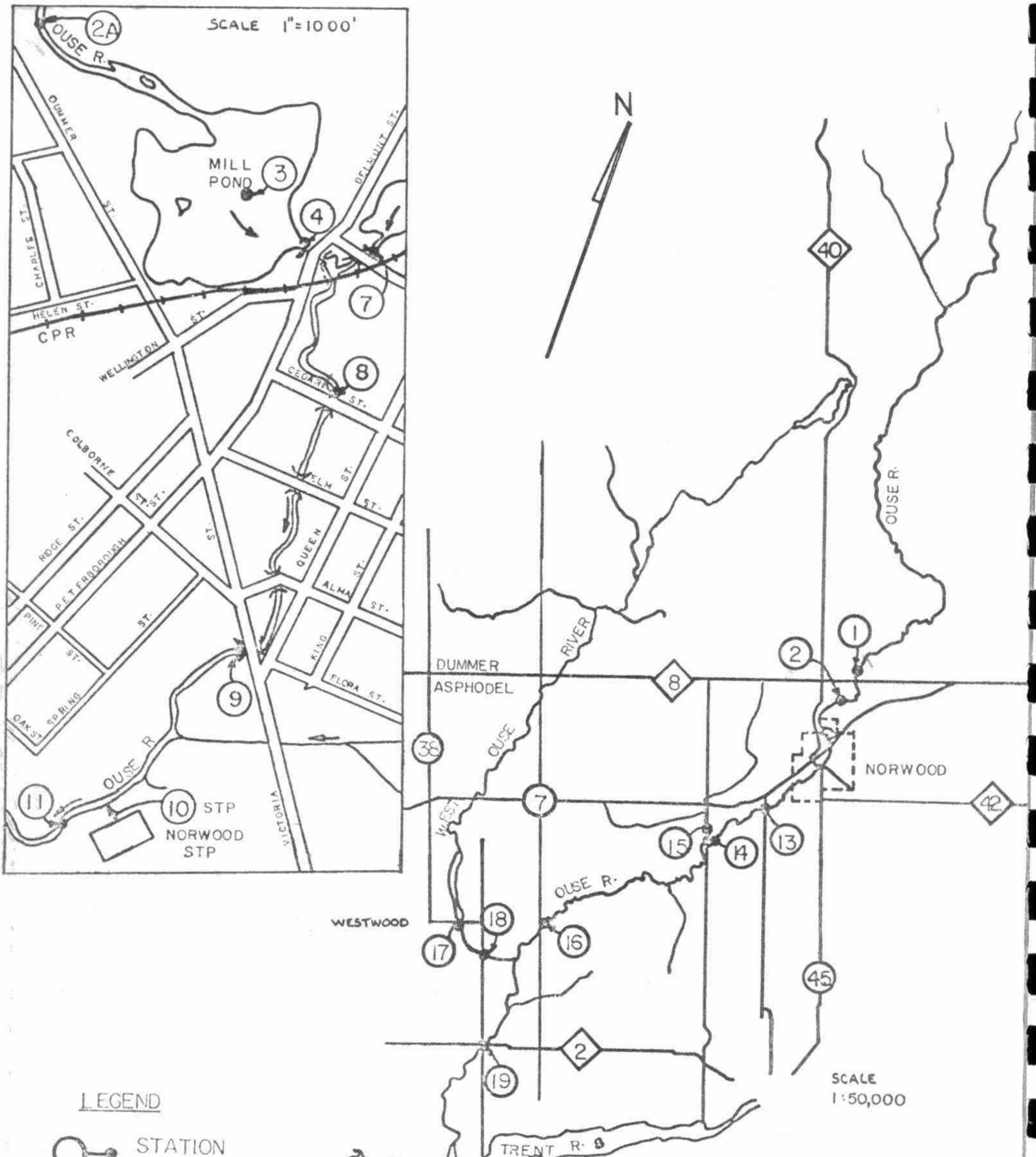
Study Area

The Ouse River is located approximately 25 km east of the City of Peterborough. There are two main branches to the stream, the west branch running through the Village of Westwood and the east branch running through the Village of Norwood (See Figure 1). Its head waters originate in Dummer Township and the river flows southward through Asphodel Township to its discharge into Rice Lake.

The drainage basin of the east branch of the river was delineated to a point just downstream of Norwood by Marshall, Macklin and Monaghan Ltd. (1977). The total drainage area of the river to Station 19 (Figure 1) was measured by staff of the Water Survey of Canada to be 109 square miles (282 square kilometres).

The basin straddles the Dummer Moraines and the Peterborough Drumlin Fields physiographic regions (Chapman and Putnam, 1973). A significant physiographic feature located in the basin is the Norwood Esker which runs for approximately 19 km and cuts across the Ouse River at the Mill Pond in Norwood.

The predominant soils in the drainage basin are Dummer Boulder Loam, Dummer Rubble Loam, Otonabee loam and muck (Department of Chemistry O.A.C.). With the exception of the latter, the soils have fair to good drainage. These soils overlay limestone bedrock of the Trenton-Black River formation.



LEGEND

STATION LOCATION

HIGHWAY

COUNTY ROAD

FIGURE 1:

OUSE RIVER SURVEY

STATION LOCATIONS 1977

The Ouse River has a variety of uses along its length including:

- livestock watering (on both branches and below their confluence);
- swimming and wading in the Mill Pond and at the Asphodel Township Park near the river mouth;
- a conservation area just upstream of Norwood using the east branch of the stream as one focal point;
- fishing (on both branches and below their confluence);
- water taking for irrigation (on both branches and below their confluence).

Procedures

The stream was sampled on a monthly basis at 14 sampling stations (Figure 1) starting December 1976. In addition, samples were also taken at a station in the Mill pond (Station 3) on five occasions. The STP effluent (Station 10 STP) was sampled by staff of Pollution Control Branch, and the plant operator as well as by staff of the Central Region, Surface Water Group during 1977.

Samples from each station were analysed for the following:

Parameter	Units
Field Measurements	
temperature	^{o}C
dissolved oxygen (D.O.)	mg/L
Bacterial Analyses	
total coliform bacteria (T.C.)	organisms/100 ml.
fecal coliform bacteria (F.C.)	organisms/100 ml.
fecal streptococcus (F.S.)	organisms/100 ml.
Chemical Analyses	
total and soluble phosphorus	mg/L
filtered ammonia (F.A.)	"
total Kjeldahl nitrogen (T.K.N.)	"
nitrite nitrogen	"
nitrate nitrogen	"
chlorides (Cl)	"
suspended solids	"
conductivity (Cond.)	umhos/cm
organic carbon (Org. C)	mg/L
inorganic carbon (Inorg. C)	mg/L

In addition to the regular sampling program, the following activities were undertaken during the survey:

1) an intensive sampling program was undertaken from July 25-28, 1977, during the low flow period of the year. Samples were collected at about 3 hour intervals during this period and analysed for the same parameters listed above with the exception of total organic and inorganic carbon;

2) time of travel between stations was measured on three occasions (March 24 and 25, May 10 to 12 and July 25 to 28). Rhodamine 'B' dye was injected into the water at an upstream station and detected with the use of a fluorometer at a downstream station. The time from injection to the peak detection at the downstream station was taken as the time of travel. Instantaneous flow measurements were also taken during the same periods at selected stations and estimated for the remaining stations;

3) quantitative samples of benthic invertebrates were obtained using artificial substrate cages (15 cm x 20 cm x 20 cm) resembling bicycle carrier baskets, filled with 4 cm crushed limestone. The cages were placed in the stream during June 6 and 7 and retrieved July 5 to 8, picked with forceps and white enamel trays. All organisms collected were preserved in 5 percent buffered formalin and identified by Central Region staff. Identifications were carried out with the use of keys by Edmondson (1959), Ross (1944), Merritt & Cummins (1978), Wiggins (1977), Klemm (1972), Crocker & Barr (1968).

4) samples of common aquatic plants were gathered and identified by Central Region staff according to Fassett (1957). Qualitative observations were made on plant densities in the river through the survey.

HYDROLOGY

Discharge from the Ouse River has been continuously recorded at the Water Survey of Canada Station 02HJ003 since 1968. Our Water Quality Station 19 was established at this location. An analysis of ten years of records at this station by Central Region staff has shown that the $7Q_{10}$ (7 day mean low flow with a 10 year recurrence interval) was 0.025 m^3/sec. Assuming that the flow at points within the drainage of the Ouse River is proportional to total flow, the $7Q_{10}$ for the river near the discharge of the Norwood STP was estimated to be 0.009 m^3/sec. The assumption of proportionality of flow was found to be reasonable for the Ouse River when checked with instantaneous flow measurements and known sub-basin areas.

To show the annual stream flow conditions in the Ouse River at Norwood STP, a low mean monthly discharge was calculated as in Appendix I.

Time of travel and flow measurements are summarized in Appendix II. Time of travel from Station 9 to 19 was about 18 hours in March and about 228 hours in July.

NORWOOD STP

The sewage treatment facilities serving the Village of Norwood during 1977, consisted of an oxidation ditch plant providing extended aeration and phosphorus removal. The plant which is owned and operated by MOE was designed for an average flow of 727 m^3/day. (0.16 MIDG which is equivalent to a discharge of 0.008 m^3/sec.). Flows and effluent quality data for 1977-1979 are summarized in Appendix III.

The plant was providing excellent treatment of organics during the year with an average BOD_5 concentration of 5.2 mg/L. The total phosphorus concentration of the effluent was relatively high during most months and averaged 1.6 mg/L as P. During winter months (January, February and December) the organic treatment was slightly less effective as indicated by elevated ammonia concentrations during these months. Fortunately, the dilution provided by the Ouse River, even during summer low flow conditions, reduces the concentration of ammonia in the stream to a level far below any concentrations that might be toxic to aquatic life.

Treatment at the plant changed little during 1978 and 1979 with slight improvement in phosphorus removal. Based on this information, conditions measured during 1977 are considered representative of present effluent quality.

DISCUSSION OF RESULTS

The results of routine sampling runs and the intensive sampling undertaken in July 1977, are summarized in Appendix IV and IV(a). Selected parameters are discussed in the following sections.

Dissolved Oxygen

Dissolved oxygen is vitally important to the plants and animals living in a stream. The members of the stream community (including plants and most animals) all breathe oxygen and plants produce oxygen during daylight hours.

Figure 2 shows that dissolved oxygen concentration over the year was fairly uniform throughout the Ouse River, including the stations downstream of the sewage treatment plant discharge. The minimum concentration measured, met the Ministry's objective for dissolved oxygen concentration in warm water streams.

During the intensive sampling in July, diurnal fluctuations in dissolved oxygen concentration were noted as shown in Figure 3. The differences between stations, relate to such things as the depth of the stream, the velocity of the stream flow, the aquatic plant growths upstream of the station, etc. The slight differences in the fluctuations between Stations 9 and 11 for example, may have been related to the increased aquatic plant growths noted in that reach. Station 13 appeared more like a pond in fluctuations because the river was broad and deeper immediately upstream of the station with heavy growths of the floating leafed plant *Lemna*. The minimum concentrations at all stations rarely went below 5 mg/L.

With lower stream flow and increased organic load from the STP, it is expected that more severe fluctuations would result with lower minimum concentrations. The measured flow in the stream at the STP during the July intensive sampling period was approximately 7 times the estimated $7Q_{10}$ value. This sampling period was the lowest flow period for the year as shown by the Water Survey of Canada (1978).

FIGURE 2 Dissolved Oxygen Concentration in the Ouse River during 1977

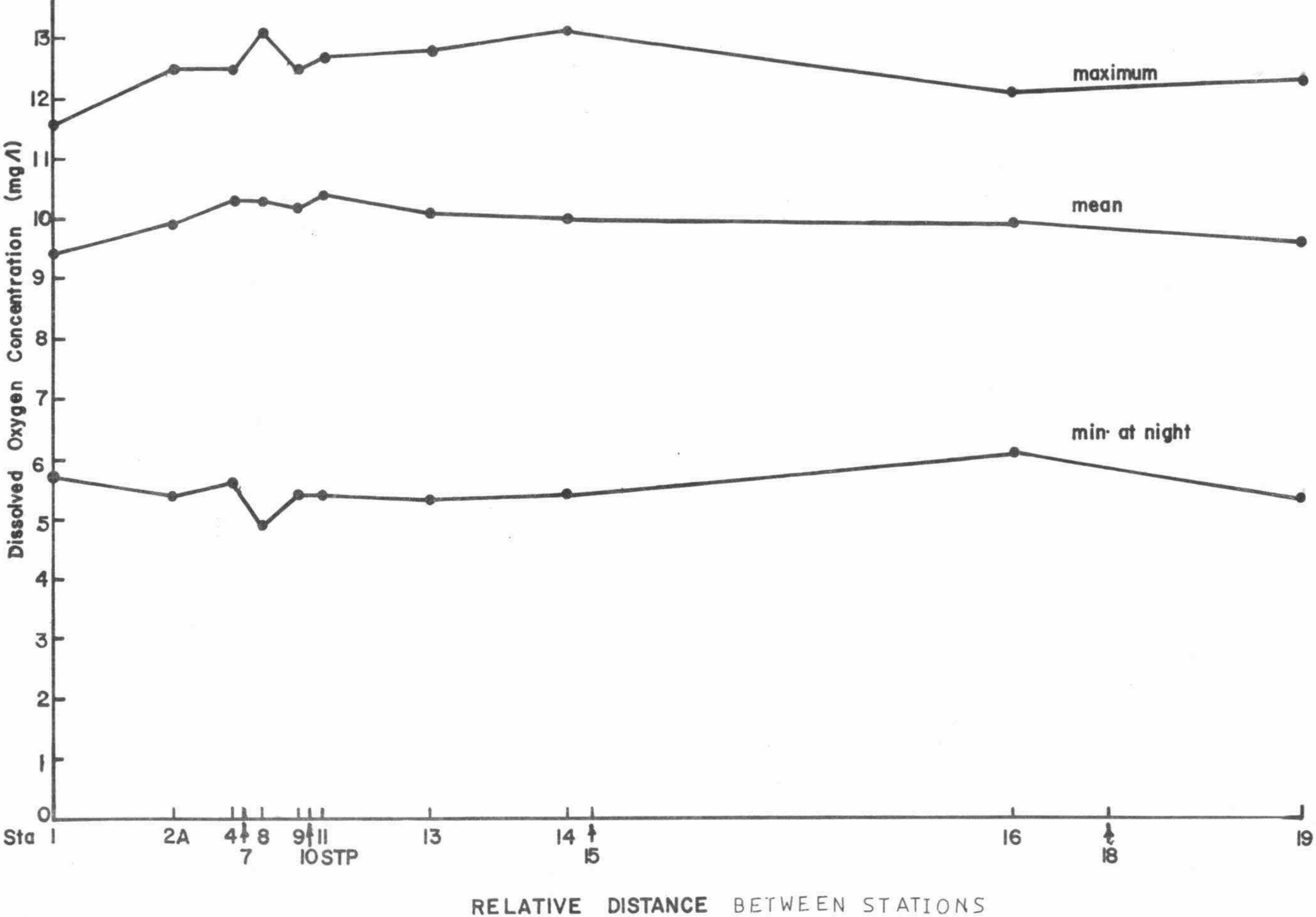
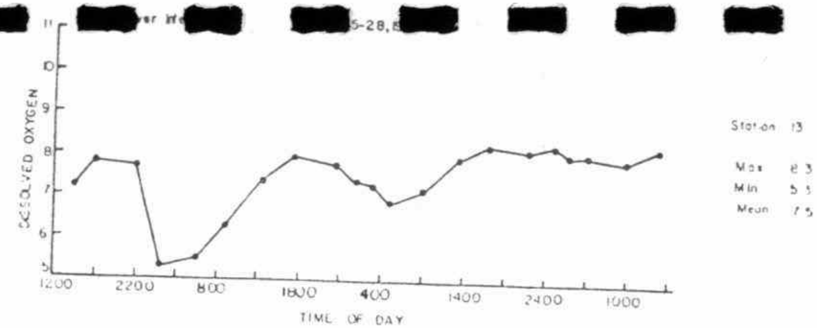
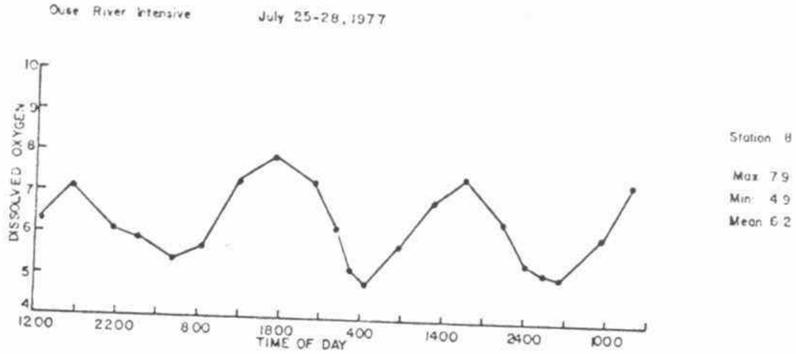
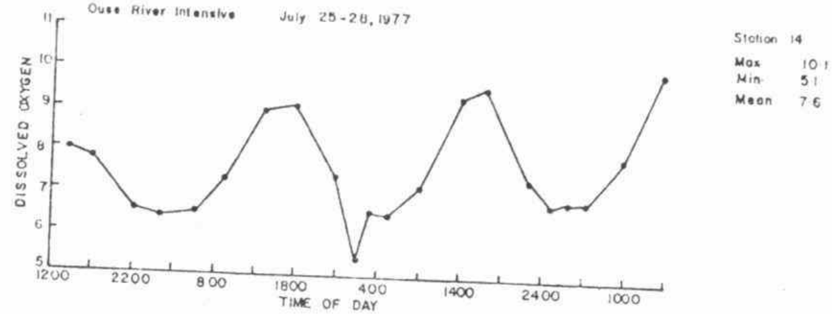
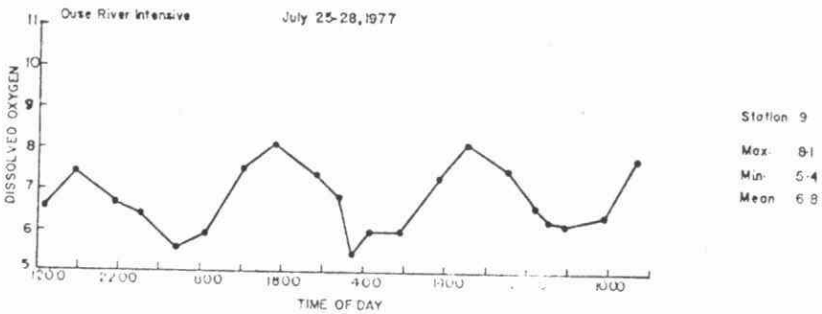


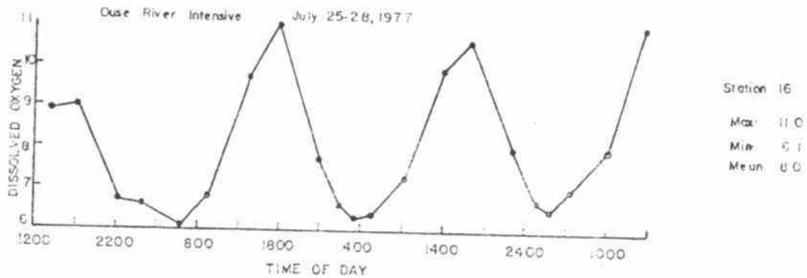
Figure 3 Diurnal Changes in Dissolved Oxygen Concentration in the Ouse River During 1977.

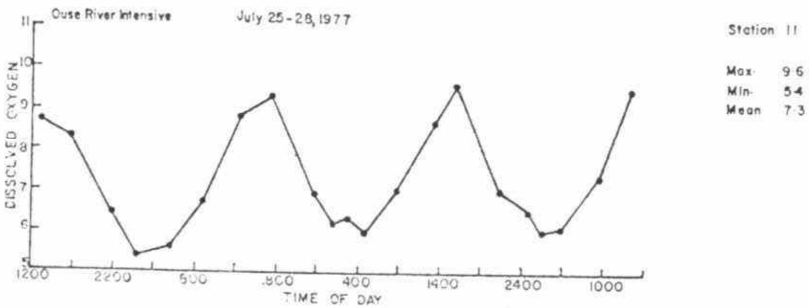


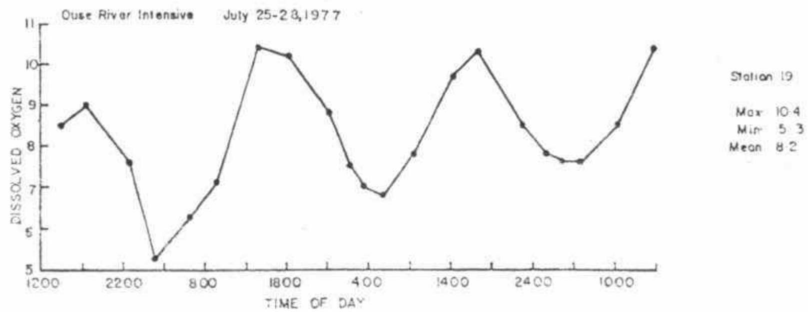












Oxygen Demand

The most frequent effect of the discharge of organic wastes to streams is the reduction of dissolved oxygen concentrations to levels which cannot support normal aquatic life. A measure of this oxygen demand in stream water is the 5-day biochemical oxygen demand or BOD_5 (defined as the dissolved oxygen required for the aerobic bacterial stabilization of decomposible organic matter in a 5-day period). An objective that is often used by this Ministry for the maximum acceptable BOD_5 concentration in a water body is 4 mg/L. Concentrations above this value may reduce the dissolved oxygen concentration below 5 mg/L and may also cause objectionable aesthetic problems.

The annual mean BOD_5 concentrations for 1977 ranged between 0.9 and 1.7 mg/L over the length of the river studied. Mean values during the intensive sampling in July ranged between 0.7 and 1.0 mg/L. Because of the excellent treatment provided at the STP, no significant increase in BOD_5 concentration was noted downstream of the STP during the critical low flow period in July.

The various sources of oxygen demand were investigated at Station 13 through the assistance of staff of Laboratory Services Branch. Water samples were analysed for long-term or ultimate BOD. The carbonaceous oxygen demand was estimated at 1.06 mg/L. With the help of staff of the Water Resources Branch, the sediment oxygen demand at Station 13 was estimated by respirometer to be 2.3 gm O_2/m^2 day. These values were low compared to other streams receiving treated sewage discharge, indicating that the STP at Norwood was having little organic effect on the river.

Nutrients

Phosphorus has been identified as a key nutrient that often limits the growth of aquatic plants. As stated in the Ministry "Blue Book" "excessive plant growth in rivers and streams should be eliminated at a total phosphorus concentration below 30 ug/L". The mean total phosphorus concentrations for 1977 at stations upstream and downstream of the STP are shown in Figure 4. The STP discharge was having a significant effect on the concentration of phosphorus in the river. The concentrations upstream of the discharge on the average were appropriate for sparse growths of aquatic plants. Downstream of the discharge concentrations were sufficient to promote excessive plant growths.

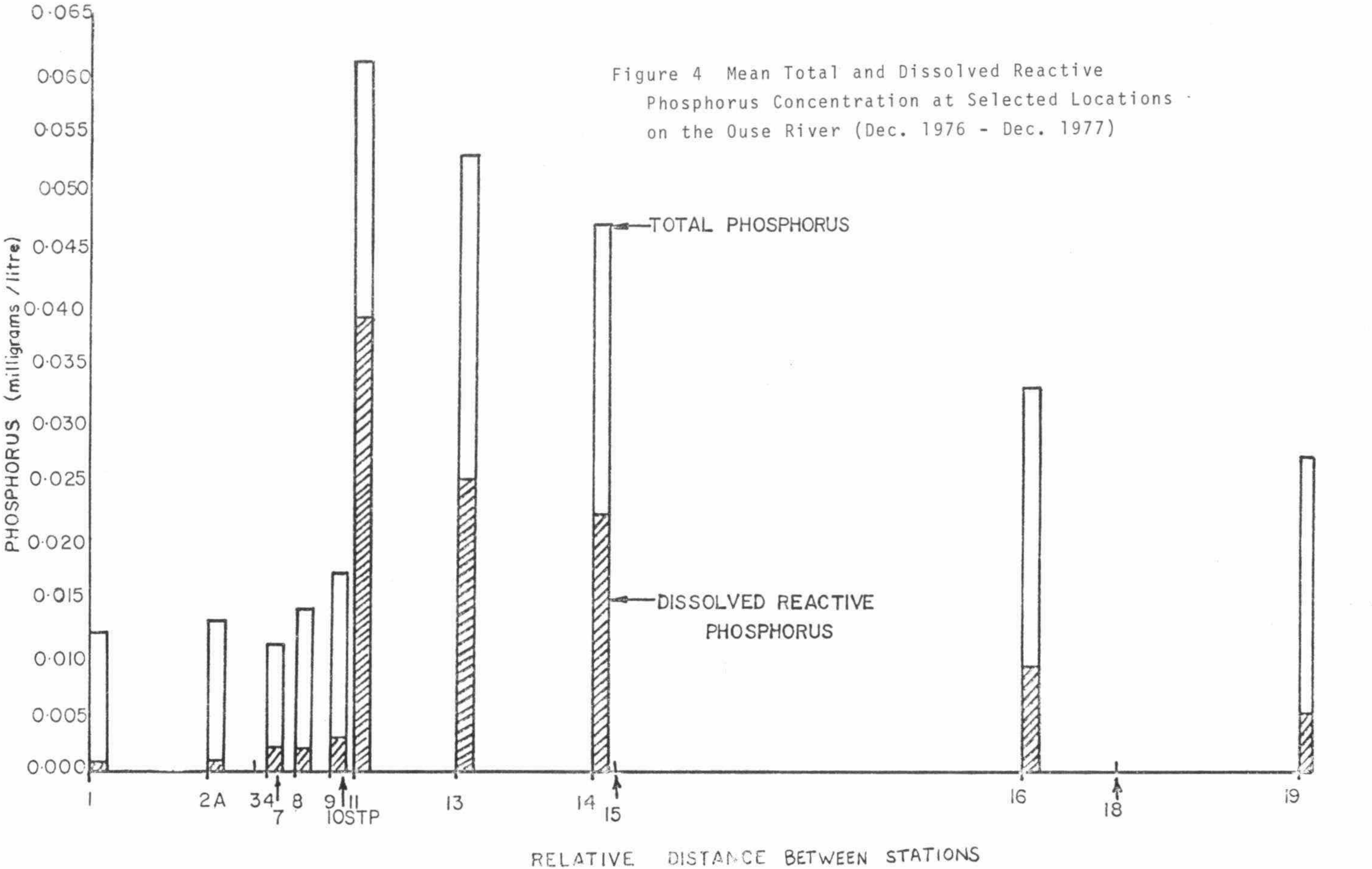


Figure 4 Mean Total and Dissolved Reactive Phosphorus Concentration at Selected Locations on the Ouse River (Dec. 1976 - Dec. 1977)

To demonstrate the relative importance of the phosphorus loading from upstream water as compared to the loading from the STP the percent of phosphorus, originating from the STP found in the downstream waters at Station 11 was calculated as in Appendix V.
It is interesting to note that a significant portion of the phosphorus carried by the stream at Station 11 originated from the STP. For most months during 1977 more than 50 percent of the phosphorus carried, came from the STP. Under low flow conditions this proportion would be even higher.

Nitrogen, another important plant nutrient was also influenced by the STP discharge. The concentrations of nitrate followed a similar pattern to that of total phosphorus. Concentrations of ammonia, however, were only elevated during the winter months. Total Kjeldahl nitrogen was not significantly affected by the discharge.

Bacteria

Samples were taken for three groups of bacteria during the survey to indicate the extent of contamination of the stream by sewage or fecal matter. Total coliform, fecal coliform and fecal streptococcus results are presented in Appendix IV and IV(a). Densities of all three indicators immediately downstream of the STP were probably affected by the discharge throughout the year.

During the July intensive survey, sufficient bacteria samples were taken for a geometric mean density to be calculated (Appendix IV(a)). Most of the stations sampled met the MOE objectives for bacteriological quality in swimming and bathing water. Throughout the year there was a definite effect of the STP discharge indicated on the bacteriological quality at the stations immediately downstream of the STP. The bacteriological quality at Station 11 did not meet the MOE objective. However, stations at points not influenced by the STP discharge also failed to meet these objectives (e.g. Station 2A, 18). There were probably other sources (in addition to the STP discharge) of bacteria such as agricultural activities contributing to the densities found in the river during this period. The period from July 25 to 28 was dry with no rainfall during the week previous to the sampling. With rainfall higher densities would be expected at all stations because of the runoff of bacteria from land (roads, rooftops, fields, etc.).

Chlorine

Total residual chlorine concentrations were measured at the STP outfall and immediately downstream of the outfall by staff of Water Resources Branch and Laboratory Services Branch on July 25 and 26, 1977. The total residual chlorine concentration at the outfall averaged 0.8 mg/L. The Ministry objective of 0.002 mg/L was exceeded in the stream to a distance of at least 36 metres from the outfall.

Despite the relatively high total chlorine residual concentration in the effluent, relatively high densities of bacteria were still being measured in the effluent.

Aquatic Plants

The growth of aquatic plants in streams is affected by many factors including the amount of available light, the nature of the stream bed, stream velocity and nutrients. In the Ouse River at Norwood, the stream velocity and nutrients changed from upstream to downstream of the STP. Flow was much more sluggish and nutrients were in much more abundant supply downstream of the STP discharge.

The common plants found in the stream included the watercress, *Nasturtium* sp. and the water buttercup, *Ranunculus* sp. as well as duckweed, *Lemna* and filamentous algae. Plant growths were noticeably denser downstream of the STP discharge during the summer. Growths at Station 13 were especially dense with duckweed frequently covering significant areas of the stream surface.

Benthic Invertebrates

Results of quantitative samples taken from six stations during July 1977 are shown in Appendix VI.

There are several factors that affect the distribution of benthic invertebrates in streams. These include:

1) physical conditions such as the presence of riffles and pools, stream flow and velocity, temperature and shading;

2) chemical conditions such as concentrations of dissolved oxygen, toxic substances, and organic matter;

3) presence of predators such as fish, leaches, crayfish, and dragonfly nymphs.

The organisms found on the artificial substrate cage placed at each station were affected by all these factors. This means that differences in the community of organisms between stations may relate to factors that were unrelated to the STP discharge.

Crayfish (Orconectes rusticus) were found at all stations in July except Station 16. This organism was probably the dominant invertebrate throughout the river in terms of biomass or size. Numerically, the mayfly, nymphs, Baetis and Stenonema and the caddisfly larvae Cheumatopsyche were most common at each station except Station 13.

The caddisfly larvae Hydropsyche, although similar in habits and shaped to Cheumatopsyche was always less abundant. Hydropsyche is considered more sensitive to higher temperatures and organics than Cheumatopsyche (Wiggins, 1977). This organism was only found at Stations 9, 14 and 16.

The Norwood STP did not appear to be affecting the benthic invertebrate community downstream of the discharge at the time of the survey. The community sampled may not have reflected "worse case" conditions because of the unusually high base flow in the river during 1977.

WATER QUALITY STATUS OF THE OUSE RIVER

The quality of water upstream of the STP was good with low organic content, relatively low mean phosphorus concentration and comparitively low aquatic plant growths. The water quality here, generally, met the Ministry's objectives.

The STP, operating below capacity, was providing excellent organic treatment during the survey. The low flow during 1977 was high in comparison to the mean low flow of previous years. Because of these factors, the impact of the discharge on downstream water quality was not "worst case" for the existing conditions. The STP was providing poor phosphorus removal during the survey.

The following parameters, measured in the downstream waters during the survey, did not meet MOE objectives or guidelines.

1) total phosphorus concentration
2) total residual chlorine concentration
3) indicator bacteria density (total coliforms, fecal coliforms)

According to qualitative observations made through the survey, heavier growths of aquatic plants were noted in the river downstream of the STP where higher nutrient concentrations prevailed. The benthic invertebrate community in the stream reflected the relatively low organic content of water upstream and downstream of the STP.

ESTIMATED STREAM IMPACT

OF STP WHEN AT DESIGN CAPACITY

To assess the effects of the STP discharge as the population of Norwood expands, a mass balance model was used as in Appendix VII that gives an approximation of downstream quality. As the population of Norwood grows to about 1600 people, the plant should reach its designed capacity (assuming a sewage production of 0.45 m^3/capita . day).

Assuming 4 mg/L as an acceptable maximum BOD_5 concentration in the stream, the maximum BOD_5 loading from the STP that the stream can assimilate was calculated to be 5 kg/day. To maintain this loading during the critical low flow period of the year, a BOD_5 concentration of no more than 7.0 mg/L must be maintained at the STP discharge at designed capacity.

To meet the MOE general guideline of 0.030 mg P/L in the downstream waters, even at 1977 sewage flows, a concentration of less than 0.040 mg P/L would be required in the STP effluent. This is technically impossible at the present time. The following treatment options are possible for the existing STP operation up to designed capacity:

1) reduce the present effluent total phosphorus concentration and maintain it at no more than 1.0 mg P/L. Even at this concentration a larger amount of phosphorus will enter the Ouse River each day to contribute to increased plant growth beyond what is presently experienced;

2) dispose of part of the effluent on adjacent farm land. This will result in an immediate reduction in the amount of phosphorus entering the river each day, and will allow a deterioration to 1977 conditions only during low flow years.

These two options would require minimal modification of the existing plant.

Ammonia concentration in the effluent was acceptable during the survey. With increased sewage flows to capacity, it will be necessary to maintain the total ammonia concentration in the effluent at 1.0 mg N/L to meet the ammonia objectives for unionized ammonia concentration during low flow conditions in the downstream waters.

Despite the relatively high total residual chlorine concentration measured at Norwood STP during July, the effluent total coliform bacteria density during the intensive sampling period was also relatively high. Present guidelines of 0.5 mg/L of total residual chlorine (using the BDH method) should be maintained as closely as possible in the plant effluent during the period May 15 to November 15. A review of this anomally and similar anomallies at other STPs is presently being undertaken by staff of the Water Resources Branch and Laboratory Services Branch.

ESTIMATED STREAM IMPACT OF STP

BEYOND DESIGN CAPACITY

Using the mass balance model, the following table shows the effluent BOD_5 concentration necessary, given various populations, to maintain a BOD_5 concentration of 4 mg/L in the downstream waters.

Population of Norwood	Effluent BOD_5 Conc. (mg/L)
1800	6.7
2000	6.4
2200	6.2

To meet these concentrations, the expanded facilities may have to incorporate the equivalent of effluent filtration into the treatment process.

The following phosphorus treatment options should be considered for an expanded STP at Norwood:

1) Maintain the present effluent total phosphorus concentration at no more than 1.0 mgP/L;

2) Reduce the effluent total phosphorus concentration and maintain it at 0.3 mgP/L;

3) Dispose of part of the effluent on adjacent farm land during the low flow period of each year. This option will provide a significant reduction of phosphorus entering the river, depending on the effluent concentration chosen and the portion disposed of on land;

4) Store part of the effluent during the low flow period of the year to be discharged in spring when good dilution is available in the stream before the growth of aquatic plants begin.

Restrictive effluent requirements of less than 1.0 mg/L total ammonia at expanded facilities, will be necessary to meet the MOE objective for unionized ammonia concentration in the stream during low flow conditions. This degree of treatment is generally not possible with the conventional extended aeration treatment offered at the plant.

In summary, water quality in the downstream waters of the Ouse River will be adversely affected with an increase in treated sewage discharge beyond the existing plant capacity unless treatment is improved. Only through a high degree of continuous treatment or effluent detention during the low flow period of the year, will an acceptable impact on the river water quality be achieved.

Under Policy 2 of the Provincial Surface Water Quality Objectives, when expansion of the Norwood STP facilities becomes necessary, a formal deviation from water quality objectives may be necessary for the waters immediately downstream of the STP discharge. This "deviation" from water quality objectives would be considered at any public hearing for the expansion and is subject to the approval of the Director, Water Resources Branch and the Regional Director.

CONCLUSIONS AND RECOMMENDATIONS

During 1977, the STP at Norwood was providing excellent organic treatment. However, because of the STP discharge the MOE guideline for total phosphorus concentration and MOE objectives for total residual chlorine concentration and indicator bacteria density were not met in the Ouse River downstream of the STP.

As the Village of Norwood increases in population and the STP approaches design capacity, the above-mentioned parameters will probably still not meet existing MOE objectives without plant or operational modification. In addition, the objective for un-ionized ammonia concentration in the downstream waters will probably not be met during low flow periods.

When the population of Norwood increases beyond the design capacity of the STP, a high degree of continuous treatment, effluent detention or land disposal during the low flow period of each year must be pursued to improve and maintain acceptable water quality in the downstream waters.

When the expansion becomes necessary, a further review of treatment options should be undertaken. Moreover, under Policy 2 of the Provincial Surface Water Quality objectives, when expansion of the Norwood STP facilities becomes necessary, a formal deviation from water quality objectives may be necessary for the waters immediately downstream of the STP discharge. This "deviation" from water quality objectives would be considered at any public hearing for the expansion and is subject to the approval of the Director, Water Resources Branch and the Regional Director.

Until the anomaly between the effluent bacteria density and total chlorine residual is resolved by staff of the Water Resources Branch and Laboratory Services Branch, the effluent chlorine residual should be maintained as closely as possible to 0.5 mg/L as total residual chlorine using the BDH method during the period May 15 to November 15.

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Appendix I   Ouse River Flows

Ouse River near Westwood, Station 02HJ003 with Drainage area = 282 Km^2

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
AVERAGE LOW FLOW*												
(cfs)	11.5	23.0	70.9	242	95.4	34.6	14.5	7.9	4.0	8.1	16.5	24.5
(m^3/sec.)	0.326	0.651	2.007	6.851	2.701	0.980	0.410	0.224	0.113	0.229	0.467	0.694

Ouse R. at Norwood STP assuming 34% of flow at Sta. 02HJ003

LOW AVERAGE FLOW	(= 34% of flows calculated above)											
(cfs)	3.9	7.8	24.1	82.2	32.4	11.8	5.2	2.7	1.4	2.8	5.6	8.3
(m^3/sec.)	0.110	0.221	0.682	2.327	0.917	0.334	0.147	0.076	0.040	0.079	0.159	0.235

calculated   7Q10 for Ouse River at Station 02HJ003 = 0.9 cfs or 0.025 m^3/sec.
assuming flow at Norwood STP is 34% of Station 02HJ003

7Q10 at Norwood STP = 0.3 cfs or 0.009 m^3/sec.

* the average of three lowest values for each month at Station 02HJ003

Appendix II Stream Flow Measurements and Time of Travel in the Ouse River 1977

Station	Time of Travel			Instantaneous Flow (cfs)				
	Mar. 24 & 25	May 11 & 12	July 25-27	Mar. 24 & 25	May 11 & 12	June 16	July 26	July 27
1				53.5	11.0	6.0	1.3	
	17 min.	27 min.						
2A				49.8	10.2	1.2	0.0	
4				61.8	31.7	5.1		
	12 min.	28 min.	6 hr. 15 min.					
8				70.9	34.9	5.6	1.5	
	34 min.	50 min.	9 hr. 40 min.					
9				78.5	30.8		1.9	1.9
	35 min.	40 min.	5 hr. 0 min.					
11				78.7*	31.0*		2.0*	2.0*
	1 hr. 52 min.	3 hr. 15 min.	24 hr. 55 min.					
13				79.7*	36.0*		2.4*	2.2*
	3 hr. 10 min.	3 hr. 32 min.	18 hr. 30 min.					
14				81.0*	37.7	6.3	2.5	2.2
	8 hr. 20 min.	12 hr. 15 min.	109 hr. 0 min.					
16				140.0*	63.8	11.5	3.1	2.8
	4 hr. 5 min.	7 hr. 20 min.	71 hr. 3 min.					
19				209.	97.4	15.7	4.4	4.8
15				17.0	3.3		0.3	0.4
18				86.8			1.8	1.6
7				10.1	3.2		0.3	

* Flows estimated using ratio of drainage areas and the measured downstream flow

Appendix III Flow and Effluent Quality Data for Norwood STP 1977, 1978, 1979

Month	Mean Daily Flow 1977 (m^3/day)	Total P. Conc. 1977 (mg/L)	1978	1979	BOD_5 1977 (mg/L)	1978	1979
Jan.	364	1.6	1.4	1.0	10.2	15.0	4.0
Feb.	341	2.4	1.0	1.0	8.8	1.2	16.0
Mar.	523	1.5	1.3	2.0	6.3	6.0	4.0
Apr.	482	1.2	0.6	5.0	1.6	4.0	5.0
May	400 - (360)	1.9	0.6	1.6	2.0	3.8	7.0
Jun.	368 - (328)	2.1	1.2	1.6	2.2	2.5	2.0
Jul.	377*- (337)	1.9	1.6	1.4	1.5	18.0	2.0
Aug.	364 - (324)	1.8	1.3	0.6	1.4	6.7	16.0
Sep.	368 - (328)	1.6	2.2	0.6	7.5	4.2	4.0
Oct.	418 - (378)	1.3	1.8	2.0	3.8	6.0	2.0
Nov.	414 - (374)	0.6	1.4	1.0	1.6	3.5	1.8
Dec.	464	1.8	1.0	0.9	16.0	2.8	6.0
Mean	407	1.6	1.3	1.4	5.2	6.1	5.8

\- minus 40 m^3/day (taken from final effluent prior to chlorination for tile field experiment)

* tile field experiment shut down for about 2 weeks for intensive survey

Effluent Quality data for 1977 Phosphorus are the combined results of samples taken by operator, Pollution Control Branch Staff and Technical Support Staff. BOD_5 data for 1977 represent the combined results of samples taken by the operator and Technical Support Staff.

Data for 1978 and 1979 provided by Municipal and Private Abatement Staff.

Appendix 1V Ouse River Sampling Results 1977 (mg/L - unless otherwise noted)

	D.O. (mg/l)	Temp °C	BOD5 (mg/l)	Bacteria / 100 ml T.C.	F.C.	F.S.	Phosphorus Total	Sol.	Nitrogens F.A.	Kjel	Nitrite	Nitrate	Cl	Susp Sol	Cond µmhos/cm	Org C	Inorg C	Tot. C
STATION	1																	
AVERAGE	9.4	8.7	0.7	171	22	26	.012	.001	.020	.41	.002	.077	2.7	5.6	443	12.8	46.1	59
MAXIMUM	11.6	20.9	1.6	900	500	344	.030	.002	.064	.70	.003	.337	3.1	20.0	930	37	57	69
MINIMUM	7.1	0.0	<0.2	30	2	4	.004	.001	.004	.24	.001	.007	2.1	1.3	350	6	12	44
STATION	2A																	
AVERAGE	9.9	8.8	0.7	236	23	68	.013	.001	.014	.50	.005	1.58	19.6	2.5	488	14.2	43.5	58
MAXIMUM	12.5	17.5	1.5	1411	234	1660	.032	.006	.059	.87	.013	5.77	48.0	4.8	740	37	67	75
MINIMUM	7.1	0.0	0.2	20	2	4	.004	.001	.004	.32	.001	0.02	2.2	0.9	355	6	11	46
STATION	3																	
December 14/76	12.1	2.0	1.0	10	4	4	.002	.001	.002	.25	.002	.093		0.6	475	8	57	65
January 13/77	7.2	2.1	1.0	16	2	2	.015	.001	.054	.28	.004	.236	3.7	3.3	570	5	61	66
February 24/77	- -	- -	1.0	40	2	4	.16	.004	.080	.30	.003	.307	3.5	8.9	475	11	52	63
April 21/77	- -	- -	0.8	84	4	2	.017	.001	.004	.36	.002	.032	2.6	4.0	370	8	37	45
June 22/77	8.4	20.7	0.8	24	12	20	.025	.001	.017	.41	.001	.009	2.7	2.8	375	11	42	53
STATION	4																	
AVERAGE	10.3	9,7	0.9	55	5	11	.011	.002	.019	.45	.002	.151	4.4	1.7	396	12.7	434	56
MAXIMUM	12.5	21.2	2.0	1147	62	70	.029	.010	.072	1.21	.004	.430	12.3	3.8	475	37	58	63
MINIMUM	7.2	0.3	0.2	4	2	2	.001	.001	.002	.21	.001	.005	2.5	0.2	330	5	12	45
STATION	7																	
AVERAGE	10.0	9.6	1.1	90	10	33	.030	.004	.084	.76	.008	.282	42.9	6.3	559	17	47.4	64.4
MAXIMUM	12.2	21.5	1.8	795	74	280	.088	.012	.284	.95	.033	1.070	63.0	30.0	720	46	65	80
MINIMUM	6.3	0.0	0.2	4	2	2	.014	.001	.008	.50	.003	.022	24.5	0.6	480	3	15	49

[redacted]pend[redacted]IV [redacted]e R[redacted]r Sa[redacted]ing [redacted]ult[redacted]77 [redacted]g/L [redacted]unless otherwise noted) [redacted]

		D.O. (mg/l)	Temp °C	BOD5 (mg/l)	Bacteria / 100ml			Phosphorus		Nitrogens				Cl	Susp Sol	Cond umhos /cm	Org C	Inorg C	Tot. C
					T.C.	F.C.	F.C.	Total	Sol.	F.A.	Kjel	Nitrite	Nitrate						
	STATION	8																	
8	AVERAGE	10.3	9.6	1.0	97	10	22	0.014	.002	.025	0.41	0.003	.160	10.6	4.9	424	13.2	43.9	57
	MAXIMUM	13.1	21.0	2.0	727	193	205	0.031	.005	.066	0.52	0.009	.605	19.5	36.0	530	36	59	73
	MINIMUM	6.2	0.1	0.2	25	2	2	0.004	.001	.004	0.29	0.002	.013	4.5	0.6	370	5	13	45
	STATION	9																	
	AVERAGE	10.2	9.3	1.0	116	13	26	0.017	.003	.028	0.43	0.004	.265	13.9	3.0	440	17	38	53
9	MAXIMUM	12.5	20.7	3.2	1700	210	278	0.039	.014	.096	0.63	0.009	.811	50.0	6.0	640	66	60	64
	MINIMUM	6.9	0.2	0.2	8	2	2	0.005	.001	.006	0.28	0.001	.063	4.8	0.5	375	4	14	35
	STATION	10 STP																	
	AVERAGE	9.3	9.6	5.2	638	31	77	1.413	1.030	2.846	4.36	0.336	13.92	95.0	6.5	947	19.4	43.4	605
10	MAXIMUM	13.4	17.0	16.0	1.4M	76000	10,000	2.660	2.250	15.00	19.80	2.350	19.20	128.0	18.0	1050	60	71	89
	MINIMUM	6.3	0.5	1.0	4	2	2	0.365	.190	.004	0.42	.001	1.14	70.0	0.5	870	7	13	25
	STATION	11																	
11	AVERAGE	10.4	9.2	1.1	528	30	54	0.061	.039	.113	0.55	.023	.989	15.1	4.2	458	12.9	43	56
	MAXIMUM	12.7	20.5	3.5	12700	1450	540	0.161	.125	.800	1.13	0.144	3.620	32.8	23.0	570	38	60	67
	MINIMUM	7.4	0.5	0.2	40	2	2	0.018	.004	.008	0.36	0.002	.286	7.1	0.5	395	5	16	42
	STATION	13																	
	AVERAGE	10.1	9.4	1.7	448	32	53	0.053	.025	.053	0.74	0.012	.716	14.9	8.0	462	12.1	43.6	56
13	MAXIMUM	12.8	21.0	7.5	35000	300	414	0.152	.071	.260	3.00	0.048	1.740	25.0	48.0	580	39	61	68
	MINIMUM	7.4	0.2	0.4	10	2	4	0.014	.003	.002	0.35	0.002	.198	6.1	0.8	370	2	13	33

Appendix IV Ouse River Sampling Results 1977 (mg/L - unless otherwise noted)

		D.O. (mg/l)	Temp °C	BOD5 (mg/l)	Bacteria/100ml			Phosphorus		Nitrogens				Cl	Susp Sol	Cond µmhos/cm	Org C	Inorg C	Tot. C
					T.C.	F.C.	F.S.	Total	Sol.	F.A.	Kjel	Nitrite	Nitrate						
	STATION	14																	
	AVERAGE	10.0	8.9	1.1	472	27	40	0.047	0.022	.090	0.58	0.010	0.805	15.1	6.1	463	13	43	56
14	MAXIMUM	13.1	20.7	2.0	9400	508	300	0.095	0.070	.560	0.88	0.025	1.970	24.0	13.0	570	38	60	69
	MINIMUM	7.6	0.3	0.2	40	2	4	0.016	0.002	.006	0.40	0.002	0.263	6.2	1.1	385	4	13	34
	STATION	15																	
	AVERAGE	9.7	8.6	1.0	196	20	32	0.019	0.004	.033	0.57	0.006	1.040	21.5	2.9	536	15	51	66
15	MAXIMUM	11.7	18.0	2.0	2700	480	600	0.044	0.011	.138	0.87	0.010	2.390	28.5	6.8	570	46	65	76
	MINIMUM	6.6	0.5	0.2	10	2	2	0.008	0.001	.006	0.16	0.002	0.261	14.0	0.7	470	3	15	54
	STATION	16																	
	AVERAGE	9.9	9.2	0.9	356	29	35	0.033	0.009	0.066	0.56	0.008	0.683	15.0	5.8	469	13	48	61
16	MAXIMUM	12.1	21.0	2.0	1500	400	580	0.057	0.033	0.278	0.67	0.019	1.790	23.0	12.0	570	40	62	71
	MINIMUM	7.9	0.2	0.1	100	2	4	0.014	.001	.004	0.48	0.003	0.216	8.0	0.9	410	2	14	41
	STATION	17																	
	AVERAGE	9.4	9.9	0.9	102	11	12	0.024	0.004	.067	0.60	0.006	0.229	8.9	3.3	428	15.5	42.6	58
17	MAXIMUM	11.8	21.2	1.8	340	48	92	0.049	0.012	0.286	0.87	0.021	0.944	16.0	12.0	570	39	65	82
	MINIMUM	6.9	0.2	0.2	20	2	2	0.006	.001	.006	0.44	0.002	0.005	5.5	0.7	299	5	14	34
	STATION	18																	
	AVERAGE	9.8	10.2	1.2	198	27	44	0.027	0.005	.065	0.64	0.006	0.202	8.9	4.9	429	14.6	46.9	61
18	MAXIMUM	12.8	22.5	2.5	430	152	247	0.045	0.016	0.284	0.78	0.018	0.526	12.0	16.0	580	38	74	88
	MINIMUM	6.2	0.1	0.2	30	4	4	0.011	.001	.002	0.48	0.002	0.012	5.7	0.9	293	6	14	35
	STATION	19																	
	AVERAGE	9.6	9.5	0.9	212	19	29	0.027	0.005	0.059	0.57	0.007	0.424	13.1	6.4	467	18.1	45	59
19	MAXIMUM	12.3	20.5	1.6	600	300	130	0.053	0.014	0.236	0.70	0.019	1.100	21.5	37.0	580	72	76	86
	AVERAGE	7.3	0.1	0.1	50	2	4	0.012	.001	.002	0.45	0.003	0.162	6.9	1.7	381	5	12	40

Appendix IVa - Mean Intensive Sampling Survey Results - July 25-28, 1977

Station	Bacteria/100 ml* T.C.	F.C.	F.S.	Tot. Phos.	F.A.	Nitrate	BOD_5
1	401	277	45	0.030	0.034	0.018	0.9
2A	1411	107	395	0.032	0.059	2.53	0.7
4	1147	46	67	0.029	0.036	0.430	0.8
7	795	62	192	0.040	0.041	0.075	0.7
8	727	193	205	0.031	0.049	0.098	0.7
9	842	210	278	0.031	0.042	0.478	0.7
10STP	2734	56	19	1.48	0.040	14.5	1.4
11	3231	213	76	0.161	0.047	3.62	1.0
13	322	44	16	0.111	0.055	1.32	0.7
14	863	508	33	0.090	0.046	0.942	1.0
15	150	15	18	0.012	0.010	1.75	0.8
16	217	70	27	0.043	0.032	0.620	0.8
17	307	41	21	0.049	0.044	0.017	1.1
18	377	152	247	0.041	0.026	0.068	0.8
19	111	30	16	0.041	0.023	0.191	0.7

*Geometric Mean

Appendix V   Phosphorus Loading for Ouse River at Sta. 9 and 10 STP 1977

Month	Phos. loading (Kg/day)	STP Phos. Loading (Kg/day)	Calculated % Phos. in stream at Stn. 11 from STP
Jan.	0.075	0.582	89
Feb.	0.162	0.818	83
Mar.	3.862	0.785	17
Apr.	1.389	0.578	29
May	0.705	0.684	49
Jun.	0.366	0.689	65
Jul.	0.204	0.640	76
Aug.	0.136	0.583	77
Sep.	0.295	0.525	64
Oct.	1.489	0.491	25
Nov.	0.797	0.224	22
Dec.	0.665	0.763	53

Appendix VI Ouse River Benthic Invertebrate Results - July, 1977 from Artificial Substrate Cages

Common Name / Family, Genus species			Sta 4	Sta 9	Sta 11	Sta 13	Sta 14	Sta 16
			Numbers of Organisms (% volume)					
Flat worms								
Planariidae			29(3)					
Animal Moss								
Paludicellidae	Paludicella	articulata					P (1)	
Segmented Worms								
Branchiobdellidae	Cambarincola			2 (1)	2 (1)	6 (1)		
Tubificidae					2 (1)	14 (1)		
unidenified							1 (1)	
Leeches								
Glossiphoniidae	Batracobdella				5 (3)	4 (1)		
Scuds								
Talitridae	Hyalella	azteci	28 (3)		5 (2)	24 (7)		
Crayfish								
Astacidae	Orconectes	rusticus	10 (70)	9 (40)	2 (30)	15 (75)	8 (11)	
Mayfly nymphs								
Baetidae	Baetis		9 (2)	43 (6)	42 (12)	3 (3)	11 (3)	53 (17)
Heptageniidae	Stenonema		17 (7)	24 (6)	17 (9)		23 (2)	10 (3)
Leptophlebiidae	Paraleptophlebia		1 (1)					
	Choroterpes		8 (3)		2 (2)		1 (1)	2 (1)
Dragonfly nymphs								
Aeshnidae	Aleshna				1 (15)	1 (1)	5 (3)	1 (5)
Damselfly nymphs								
Coenagrionidae								
	Ischnura		9 (5)			3 (.5)		

.../b

(b)

			Sta 4	Sta 9	Sta 11	Sta 13	Sta 14	Sta 16
Stoneflies								
Perlidae	Perlesta							15 (6)
Bugs								
Corixidae						12 (4)	1 (1)	
Helgramites								
Sialidae	Sialis		1 (1)		2 (2)			
Corydalidae	Nigronia						2 (6)	
	Chauliodes							1 (5)
Beetles								
Psephenidae	Psephenus			2 (2)				
Elmidae	Stenelmis			265	1 (1)	1 (1)	38 (4)	130 (7)
	Ordobrevia	nubifera?		2 (1)			5 (1)	
Dytiscidae								1 (1)
Caddisfly larvae and pupae								
Brachcentridae	Brachycentrus						77 (8)	7 (2)
Helicopsychidae	Helicopsyche							2 (2)
Hydropsychidae	Hydropsyche			98 (2)			8 (1.5)	80 (5)
	Cheumatophsyche			394 (8)	7 (1)	1 (.5)	63 (6)	213 (20)
Hydroptillidae	Ochrotrichia							5 (1)
Limnephilidae	Pycnopsyche				5 (20)		21 (42)	3 (7)
Polycentropodidae	Neureclipsis		18 (4)		2 (1)	1 (.5)	6 (1)	20 (5)
Fly larvae								
Chironomidae			40 (2)	2 (1)	28 (4)	65 (7)	8 (1)	8 (1)
Simuliidae	Simulium							1 (1)
Snails								
Physidae	Physa					3 (7)		
Ancylidae	Ferrissia			9 (2)			1 (1)	
Total number per cage			170	611	123	153	279	552

Appendix VII Calculation of Loadings and Concentrations Using Mass Balance Model

The formula,

$$(q_{us} \times C_{us} \times 5.4) + (q_{STP} \times C_{STP} \times 5.4) = (q_{ds} \times C_{ds} \times 5.4)$$

where q_{us} = flow upstream of the STP discharge in cfs

C_{us} = upstream concentration of parameter of interest in mg/L

q_{STP} = flow of the STP discharge in cfs

C_{STP} = concentration of parameter in effluent in mg/L

q_{ds} = $q_{us} + q_{STP}$ in cfs

C_{ds} = concentration of parameter downstream of STP discharge after complete mixing mg/L

5.4 = factor resulting in load in. pounds/day

was used to calculate the expected concentration or loading of a desired parameter.

eg. q_{us} = 0.3 cfs (low flow conditions)
C_{us} = 1.0 mg BOD_5/L
q_{STP} = 0.3 cfs (design flow for about 1600 people)
C_{STP} = ?
q_{ds} = 0.6 cfs
C_{ds} = desired BOD_5 concentration of 4.0 mg/L

$$(0.3 \times 1.0 \times 5.4) + (0.3 \times C_{STP} \times 5.4) = (0.6 \times 4.0 \times 5.4)$$

$$CSTP = \frac{12.96 - 1.62}{1.62} = 7.0 \text{ mg/L}$$

Therefore, to maintain a BOD_5 concentration in the stream below the STP of 4.0 mg/L, a concentration of no more than 7.0 mg/L must be maintained in the effluent at designed plant capacity, during low flow conditions.

Ontario

Ministry of the Environment

Central Region

Suite 700
150 Ferrand Drive
Don Mills, Ontario
M3C 3C3
(416) 424-3000

March , 1980

Dear Sir/Madam:

Re: Water Quality of the Ouse River
at the Village of Norwood, County of
Peterborough

Attached for your information is our report entitled "Impact of the Village of Norwood Sewage Treatment Plant Effluent on the Water Quality of the Ouse River, County of Peterborough".

The report concludes that the existing water quality of the Ouse River upstream of the sewage treatment plant discharge met provincial objectives. As a result of the discharge, the general guideline for total phosphorus concentration and the Ministry objectives for total residual chlorine concentration and indicator bacteria density were not met in the waters downstream of the plant.

As the Village of Norwood increases in population and the design capacity of the sewage treatment plant is reached, the above-mentioned parameters will probably still not meet existing objectives without modification to either the plant operation or design. In addition, the objective for un-ionized ammonia concentration will probably not be met during low flow conditions.

Any further expansion of the facilities will require a high degree of treatment to ensure that the water quality in the downstream waters does not deteriorate further.

The initial distribution list for the report is attached. If you wish to suggest additions to this list or wish to discuss the report further, please feel free to contact this office.

Yours truly,

C.J. Macfarlane,
Regional Director.

IMPACT OF THE VILLAGE OF NORWOOD

SEWAGE TREATMENT PLANT EFFLUENT ON

THE WATER QUALITY OF THE OUSE RIVER

COUNTY OF PETERBOROUGH

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Richmond Hill, Ontario
L4C 3C9

C.R. Gray
District Manager
Ministry of Natural Resources
322 Kent Street West
Lindsay, Ontario
K9V 2Z9

A. Beaumont
Director
Community Planning Advisory Branch
Ministry of Housing
60 Bloor Street West
8th Floor
Toronto, Ontario
M4W 3K7

Director
Subdivisions Branch
Ministry of Housing
56 Wellesley Street West
8th Floor
Toronto, Ontario
M7A 2K4

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Attention: Ms. Eva Marron

D. Kelloway
Secretary-Treasurer
Seven Links Planning Board
Box 190
Havelock, Ontario
K0L 1Z0

J.D. Armstrong
County of Peterborough
County Court House
Peterborough, Ontario
K9H 3M3

E.A. Wright
Secretary-Treasurer
Otonabee Region Conservation Authority
727 Lansdowne Street West
Peterborough, Ontario
K9J 1Z2

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Township of Asphodel
R.R. #3
Hastings, Ontario
K0L 1Y0

D. Clifford
Clerk-Treasurer
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K0L 3A3

R. Althouse
Clerk-Treasurer
Village of Norwood
78 Colborne Street
Norwood, Ontario
K0L 2V0